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AN INTERFACE TO A MICROCOMPUTER FOR A MULTICHANNEL DATA LOGGER --ETC(U)

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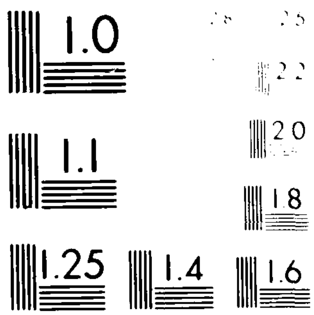
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TECHNICAL MEMORANDUM

ERL-0196-TM

AN INTERFACE TO A MICROCOMPUTER FOR A MULTICHANNEL DATA LOGGER RECORDING SPECTRAL RADIANCE MEASUREMENTS

F.S. CRISCI

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AN INTERFACE TO A MICROCOMPUTER FOR A MULTICHANNEL DATA LOGGER RECORDING SPECTRAL RADIANCE MEASUREMENTS

F.S. Crisci

S U M M A R Y

Two multichannel data loggers making spectral radiance measurements in the range 0.4 μm to 1.0 μm, are described. Their data products and interfacing to a microcomputer is discussed. The collection of data and its permanent storage using a floppy disk drive is described.

POSTAL ADDRESS: Chief Superintendent, Electronics Research Laboratory, Box 2151, GPO, Adelaide, South Australia, 5001.

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1. INTRODUCTION

Spectral radiance measurements sometimes involve the collection of large quantities of data over relatively short periods of time. An example of this is when airborne multichannel radiometric equipment is used to obtain detailed spectral signatures to ground-truth remotely sensed data. It is essential to coordinate the collection and ordering of this data, and its storage in a medium that will provide a ready means of retrieval.

One such arrangement is the use of a microcomputer to control the data logging, and a floppy disk drive for mass data storage. When data is written onto the diskette using a standard format, the stored information is readily addressable.

Under Direct Memory Access (DMA) control, blocks of data can be transferred between the multichannel data logger and the Random Access Memory (RAM) of the microcomputer, and then be rewritten onto the diskette.

In the initial development stages, the software to operate this system will reside on a special diskette and be down-loaded into a reserved area of RAM using a Programmable Read Only Memory (PROM). When no further changes are required the diskette-resident software will be written into Read Only Memory (ROM) for permanent storage.

2. SPECTRAL RADIANCE MEASURING EQUIPMENT

Two instruments for making spectral radiance measurements have been designed and constructed: a rapid scanning spectroradiometer that uses a raster scan pattern to scan a matrix array of silicon photodiodes and a 16 channel radiometer that uses a linear array of 16 photodiodes. Since the measurements are made electronically, these radiometers can have a decided reliability advantage over the more traditional mechanical radiometers.

2.1 The spectroscope

The spectral dispersion system is essentially a spectroscope that focuses a spectrum of the radiation source onto the photo-sensitive surface of the particular radiometer. Radiance measurements are made in the wavelength range 400 nm to 1000 nm, covering the visible and near infrared bands of the spectrum.

2.2 Rapid scanning spectroradiometer

The rapid scanning spectroradiometer shown in figure 1 consists of a television camera with additional circuits to control the scanning of the camera, and an Analogue to Digital converter to digitize the video output. The data are digitized into 8 bit bytes to make them compatible with the microcomputer 8 bit data bus system(ref.1).

The spectrum is dispersed over the tube face such that the spectral lines are parallel to the scanning lines. In this way the spectrum may be divided into bands, each band being a fraction of the total number of scanning lines. The spectral resolution of course is governed by the number of lines included in each band. Unlike a normal television raster scan pattern, no interlacing is used in a scan of the spectroradiometer. Thus only 300 lines constitute one scan of the tube face.

For absolute spectral measurements, a facility is included for collecting two spectra simultaneously. The input optics is arranged in such a way that a reference source spectrum may be dispersed over one half of the

camera tube face while the spectrum of the radiation reflected from the sample is dispersed over the other half. (See figure 2).

When the dual-spectra facility is used, 2 sets of interleaved data are presented to the interface with the microcomputer. This situation is recognized by the microcomputer which then discriminates the incoming data and keeps the 2 spectra records separate. The procedure followed is fully described in Section 2.4.1.

2.3 The 16 channel radiometer*

An alternative device has been developed to collect spectral signatures. This is a 16 channel radiometer which incorporates a set of 16 spectral filters that each transmit a narrow band of wavelengths onto one of 16 discrete photodiodes. The analogue output of each photodiode is digitized in turn by a 16 channel Analogue to Digital (A/D) converter into an 8 bit byte, so that 16 bytes of data are generated per run of the 16 channel radiometer.

2.4 Data management system

A microcomputer is used to automate the collection of the spectral data from the two radiometers and the subsequent logging of data onto a permanent storage medium. The permanent storage medium is the floppy disk drive, selected mainly for its easy interface to microcomputers. (Appendix I).

To describe how the microcomputer controls the operations of the 2 radiometers and the floppy disk drive, it is necessary to look separately at how each device interfaces to it.

2.4.1 Interface to rapid scanning spectroradiometer

The interconnections that provide the interface between the scanning radiometer and the microcomputer are:

(a) 8 bit data port

(b) 4 bits giving pre-frame delay setting

(c) 8 bits giving the number lines per band

(d) 4 lines for interfacing to the DMA card

(e) a "Go" signal

(f) an earth

(g) the "MEMR" (Memory Read) signal

When the scanning radiometer is selected, the 16 channel radiometer is automatically disabled from requesting service until completion of data collection by the scanning radiometer. The exchange of data between the scanning radiometer and the RAM of the microcomputer is controlled by the DMA integrated circuit. (The DMA is capable of controlling 4 channels of data input).

Upon receipt of a request for data collection, a "Go" signal is issued to the scanning radiometer. This is then used to trigger the circuitry to process and assemble a byte of data onto the microcomputer's data bus system. When the byte has been assembled, the radiometer raises a request to the DMA.

When the dual-spectra facility is used, two such requests are raised consecutively. The resulting interleaved data is accounted for by enabling the "rotating priority" bit in the control word of the DMA. This means in effect that the data from spectrum 1 are routed to one area of RAM, and that from spectrum 2 to another area of RAM. In this way, the two sets of data are kept distinct for subsequent processing and analysis.

The data are then transferred from RAM, and written out to diskette following the most recently stored data.

2.4.2 Interface to 16 channel radiometer

The 16 channel radiometer has a fixed spectral resolution, and the analogue photodiode outputs are presented to the 16 channel A/D converter simultaneously. When data are to be collected, each channel in turn is converted and the resulting byte shifted into a reserved area of RAM. When enough readings have been taken to fill one sector of diskette space, the data in RAM are written out to the magnetic diskette (one sector holds 8 x 16 = 128 bytes).

As with the scanning radiometer, once the 16 channel radiometer request line has been recognized, all other requests are disabled until the completion of data collection.

2.4.3 Interface to floppy disk drive

The single density, single read/write head floppy disk drive provides the means of storing either formatted or unformatted data on a magnetic diskette. The data capacity of a formatted diskette using the IBM 3740 standard format is 250 000 bytes (see Appendix I) while an unformatted diskette is 400 000 bytes.

To write data onto diskette, the following sequence of initialization events takes place:

(i) Registers in the floppy disk controller integrated circuit are loaded and the drive enabled, to position the read/write head over the required track and sector on diskette.

(ii) The DMA are initialized with the starting location in RAM from which data that is to be written onto diskette, will be read.

(iii) The DMA "byte-count" register is loaded with the number of bytes of data to be transferred, and the direction of transfer (either from RAM to peripheral or peripheral to RAM).

(iv) The DMA channel is enabled with the necessary options such as rotating priority, terminal stop count and extended memory write.

(v) The "WRITE MULTIPLE SECTORS" command is issued to the disk.

Once initiated, the data transfer continues until either:

(a) the end of a diskette track is reached, or

(b) the DMA has finished transferring the number of bytes for which it was initialized.

In case (a), it is then necessary to evaluate how much data in RAM still needs to be written out to the diskette. The DMA must then be re-initialized and the read/write head of the disk drive repositioned to the beginning of the next track (according to steps (i) to (v) above).

The RAM capacity is 12 288 bytes and one track on a formatted diskette holds 3 328 bytes. Thus to completely transfer the RAM capacity out to diskette requires at least 4 DMA initializations and 4 different positionings of the disk drive read/write head.

To retrieve the recorded data from diskette, the procedure described by steps (i) to (v) above is followed, with a change to the direction of data transfer and now the replacement of the "WRITE MULTIPLE SECTORS" command with "READ MULTIPLE SECTORS". The disk drive read/write head must be positioned to the track and sector from which the data to be retrieved starts. To set the DMA byte-count register it is also necessary to have recorded the number of bytes that were transferred when the data were originally written out to diskette. When a block of data is transferred across from RAM onto diskette, a record is made of the read/write head starting and ending position. Thus the start of the data and the number of sectors used in the transfer are recorded.

Each time data needs to be written to the diskette, a check is made of the current track number. If it is calculated that the next data transfer requires more than the diskette space remaining, the microcomputer indicates that a new diskette must be loaded. If the disk drive door is closed without a diskette having been loaded, no action takes place until the user loads a diskette. This diskette is then checked for protection against being written on.

3. DESCRIPTION OF SOFTWARE

The composition of the software determines the characteristics of the microcomputer. The software is divided into five main areas (see figure 3). Initialization, Monitoring, Servicing, Data onto Diskette and Directory Entry.

3.1 Initialization

The following assignment of diskette space is made for the respective data:

(i) track 1 - reserved for scanning radiometer data directory,

(ii) track 2 - reserved for 16 channel radiometer data

(iii) track 3 to 76 - reserved for scanning radiometer data

Also, 128 locations are reserved in RAM to store the 8 sets of 16 channel radiometer readings before they are written out as one sector of diskette space on track 2. Finally all request lines are enabled and the interface devices are programmed to operate in the required mode (see figure 4).

3.2 Monitoring

The software has been written so that only one radiometer collects data at any one time. The request lines are monitored and are subsequently disabled so no interruptions to the radiometer collecting the data can occur when a request is entered. An indication of the radiometer in current use is provided. (See figure 4).

3.3 Servicing

The 2 radiometers are serviced by different routines. The scanning radiometer can output varying amounts of data (depending on the resolution set), whilst each run of the 16 channel radiometer results in 16 bytes of data being collected; the scanning radiometer requires 6 "hand-shaking" signals (the required sequence of signals to and from the microcomputer, required for communication between peripherals and the microcomputer) and the intervention of DMA, whilst the 16 channel radiometer does not require any hand-shaking signals, or DMA.

3.3.1 The 16 channel radiometer

The 16 channel radiometer presents analogue signals to its interface with the microcomputer. When a request for data is made, the microcomputer zeros the channel-number register (so that it starts from 0 and ends with channel 15) and enables channel 0 of the A/D converter. Upon completion of conversion, the resulting byte is transferred into the reserved area of RAM, the channel-number register is incremented and the next channel is enabled. When all 16 channels have been converted, a check is made of the number of readings taken. If sufficient to fill one sector on the diskette the 128 bytes are written out to the diskette; otherwise, all request lines are reset and re-enabled, and a new request can be entered. (See figure 5).

3.3.2 Rapid scanning spectroradiometer

The number of bytes output from a run of the scanning radiometer is dependant on the resolution set, the number of spectra (single or dual), and the number of fields taken with these parameters. To program the DMA controller for the transfer of data between the scanning radiometer and RAM, the expected number of bytes (called T, for "the total") is calculated for each run of the scanning radiometer. As the amount of RAM is limited to 12 288 bytes, T is checked to ensure that it does not exceed the available RAM. Should it do so, the DMA is set to transfer a maximum of 12 288 bytes (in the case of dual-spectrum, 6 144 bytes per channel); if T does not exceed the available RAM, the DMA is set to terminate on transferring T bytes.

With the DMA controller set, the "Go" signal is issued to the scanning radiometer to initiate its electronics. Each byte is shifted into RAM and when the DMA controller has ended the transfer, the data are ready to be transferred onto the diskette. (See figure 6).

3.4 Data onto diskette

One track of diskette space has been allocated for data collected from the 16 channel radiometer. This allows for 208 readings per diskette, a number which should adequately cover the requirements. No label is added to this data before storing on diskette, as each reading produces 16 bytes, and the data is stored in consecutive sectors on the reserved diskette track. (See figure 7). In the case of the scanning radiometer both the data and an accompanying label are written onto the diskette. This label is necessary

to record the number of lines per band, the number of spectra (single or dual) and the pre-frame delay, that were used when the measurements were made.

Thus when this label is coupled with the respective disk directory entry all the information about the particular data collected will be known.

Before any data are written, a check is made that enough diskette space is available to record T, "the total" number of bytes calculated. If insufficient, this condition is indicated and a new diskette must be loaded. The drive is always checked for the presence of a diskette. Once in the drive, the diskette is checked for protection against being written on. The DMA controller is then programmed for the exchange between RAM and diskette, and is reprogrammed as many times as necessary to completely copy the data collected onto the diskette, since each new set of data overwrites the old set of data, in RAM. (See figure 8).

3.5 Directory entry

The purpose of the directory is to maintain a record of the parameters associated with each run of the scanning radiometer, and the location on diskette of the start of the data collected with these parameters.

Therefore, a directory entry consists of the following 8 bytes:

(i) 2 bytes to store the date,

(ii) 2 bytes for the run number of that day,

(iii) 2 bytes for the number of bytes of data generated from the run,

(iv) 2 bytes for the track and sector numbers of the start of the data.

When the user wishes to retrieve the data from a run of the scanning radiometer, he enters the date and run number. A search is made of the directory for these entries and the track and sector numbers can subsequently be found. The data can then be read off diskette into RAM and processed. The label associated with the recorded data contains the number of lines per band, pre-frame delay, and the dual-spectra status used for this run. (See figure 9).

3.6 Object code

In the system development stage, not all the RAM has been used for storing spectral data. In fact only 8 192 bytes of the 12 288 bytes total RAM are used for data, and the other 4 096 bytes are used to hold the software. A Programmable Read Only Memory (PROM) holds the instructions that actuate the down-loading of the diskette-resident software into this 4 096 byte area of RAM. (It resides on diskette because RAM is a volatile storage medium). Thus when the equipment is switched on, the software is read from the diskette, loaded into RAM and the microcomputer is then ready for use. When the software is at the stage when no further changes are needed, it will be transferred from diskette onto a PROM, thus freeing the other 4 K bytes of RAM for data.

The software was developed, compiled and converted to object code using an Intel 8080 Macro-Assembler package. The object code is contained in a user data set and is loaded into the microcomputer using a facility developed by the author and P.J. Whitbread. This facility uses an ASCII port to download the object code to RAM and then transfer it to floppy disk for

permanent storage.

4. DISCUSSION

The rapid scanning spectroradiometer is a device that can be used for any optical measurements where high spectral resolution is required. Since the instrument's interface to the microcomputer is based on input of data via the 8 bit data port, and various hand-shaking signals to control the transfer of data into RAM, any spectral radiance measurements may be made and logged by the microcomputer. This means in effect that, if required, the spectroradiometer could be operated as a 600 (2 x 300) channel data logger when the dual spectrum facility is used. Alternatively since the 2 blocks of data (one from spectrum 1 and one from spectrum 2) are treated separately and read into separate areas of RAM, absolute measurements can be made when one half of the tube face of the spectroradiometer is illuminated with a standard source.

If repeated, unmanned measurements at fixed resolution need to be made, the system could be made to operate as follows:

(i) Data is collected until the RAM is filled,

(ii) data is transferred onto the diskette, until the diskette is filled,

(iii) an alarm is raised when the diskette is filled, whereupon the user loads a new diskette and reinitializes the system. Alternatively the data on diskette could in turn be transferred to another mass storage medium, (eg paper tape). The diskette could then be erased, reinitialized and used again, for new data.

Using the dual spectrum facility at maximum resolution (1 line per band) yields 600 bytes per field. With in excess of 12 K bytes of RAM available, 20 fields can be taken before the RAM is filled. At this rate of data exchange, a diskette would be filled in:

$$\frac{\text{74 tracks x 26 sectors x 128 bytes per sector}}{\text{12 288 per exchange}} = \frac{74 \times 26 \times 128}{12\ 288} \sim 20 \text{ exchanges}$$

Thus a diskette will hold 400 fields of scanning radiometer data at maximum resolution using the dual spectrum facility.

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No.	Author	Title
1	Brophy, H.J., Whitbread, P.J. and Crisci, F.S.	"Design of a Rapid Scanning Spectroradiometer". ERL-0174-TM, September 1980
2	Western Digital Corporation	"FD 1771-01 Floppy Disk Formatter/Controller". Data Sheet; Western Digital Corporation, December 1976
3	Whitbread, P.J.	"Rapid Scanning Spectroradiometer". (In preparation)

APPENDIX I

A COMPARISON OF THE FLOPPY DISK DRIVE WITH OTHER MASS STORAGE MEDIA

Random Access Memory (RAM) is a volatile means of storing data, so that when the power is disconnected, all the data contained in the memory is lost. This fact points out the need for a permanent storage medium, some examples of which are paper-tape, magnetic cassette tape, magnetic bubble memory, and the floppy diskette.

Paper tape is a very slow and awkward means of outputting data and is therefore not suitable for many applications.

As yet, no universal standard interfaces exist for magnetic cassette tape transports, making it possible for a transport to be compatible with one system but not with another. Its data transfer rate is somewhat restrictive for fast data transfers (typically 12 K bits/s), but the main disadvantage is the inherent slow retrieval of data from a recording medium of this kind.

Although Magnetic Bubble Memory represents a more compact non-mechanical mass storage medium, its implementation is still relatively in its infancy and essentially untested. There is an improvement in memory access time over the floppy disk (40 ms as opposed to 240 ms) but the maximum data rates are of the order of 200 K bits/s in comparison to 250 K bits/s with the floppy disk.

The single density, single read/write head floppy disk drive provides the means of storing data on diskette in either a formatted or unformatted manner. The data capacity of the unformatted diskette for a single density single read/write head drive, is 400 K bytes. To provide flexibility of analysis on either the microcomputer or a main-frame computer, the data is recorded in the formatted form. This format (IBM 3740) is used by most manufacturers of floppy disk drives and controllers. It reduces the diskette data capacity to 250 K bytes.

Each of the 77 tracks on the diskette is segmented into 26 sectors (each of 128 bytes), data and address marks and various inter-record gaps. In this way information is stored as physical records in addressable locations on the recording surface of the diskette.

The data will be disposed on the diskette as follows:

(i) Track 0 is reserved as a diskette directory for the purposes of a floppy diskette reader.

(ii) Track 1 is reserved as the data directory track for the scanning radiometer.

(iii) Track 2 is reserved as the track for 16 channel radiometer data.

(iv) Tracks 3 to 76 are reserved for scanning radiometer data.

Strictly speaking, tracks 75 and 76 are intended to be reserved for use as replacements (alternative tracks) for defective tracks, but in this application will be used for storing more data.

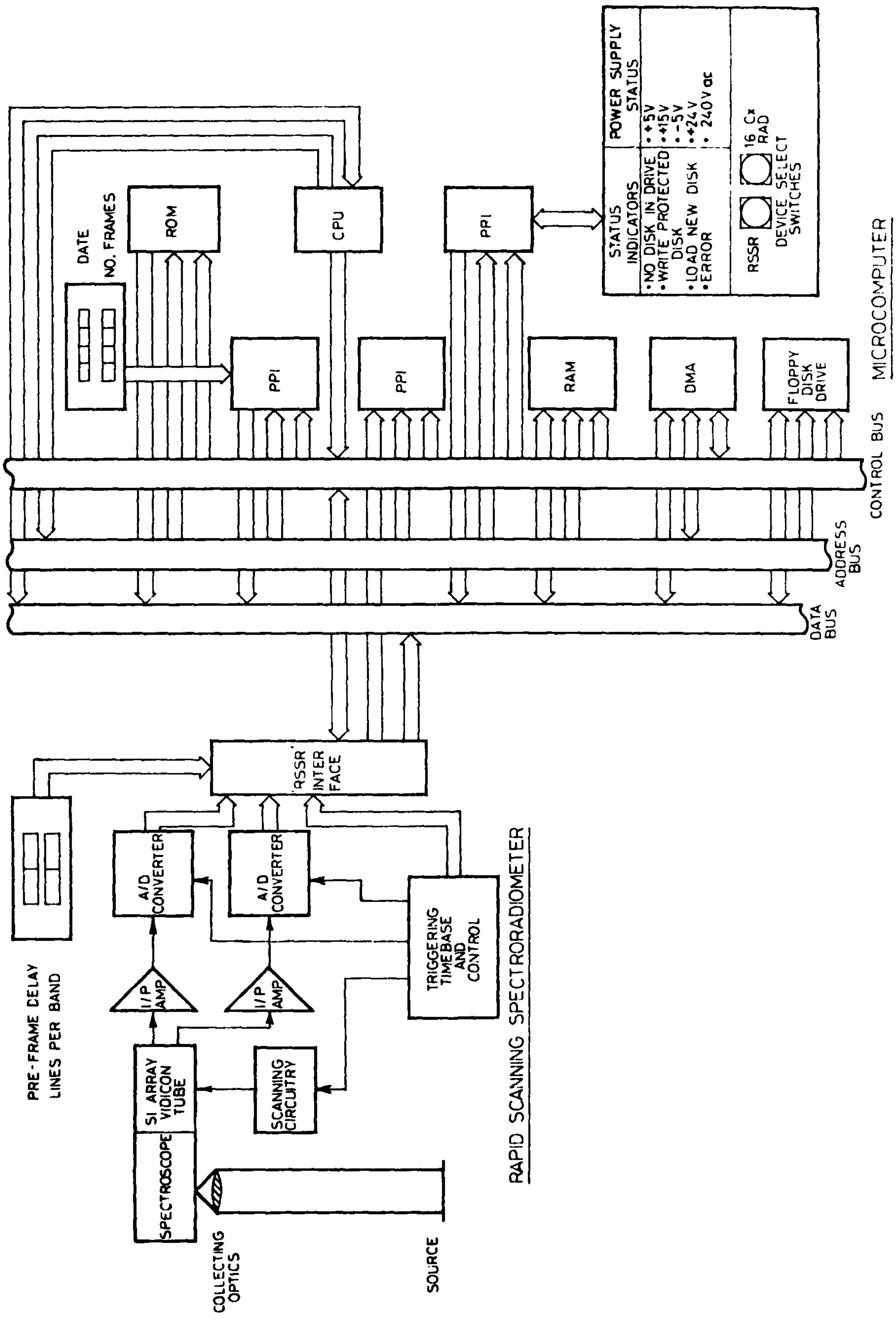

Figure 1. Rapid scanning spectroradiometer and microcomputer

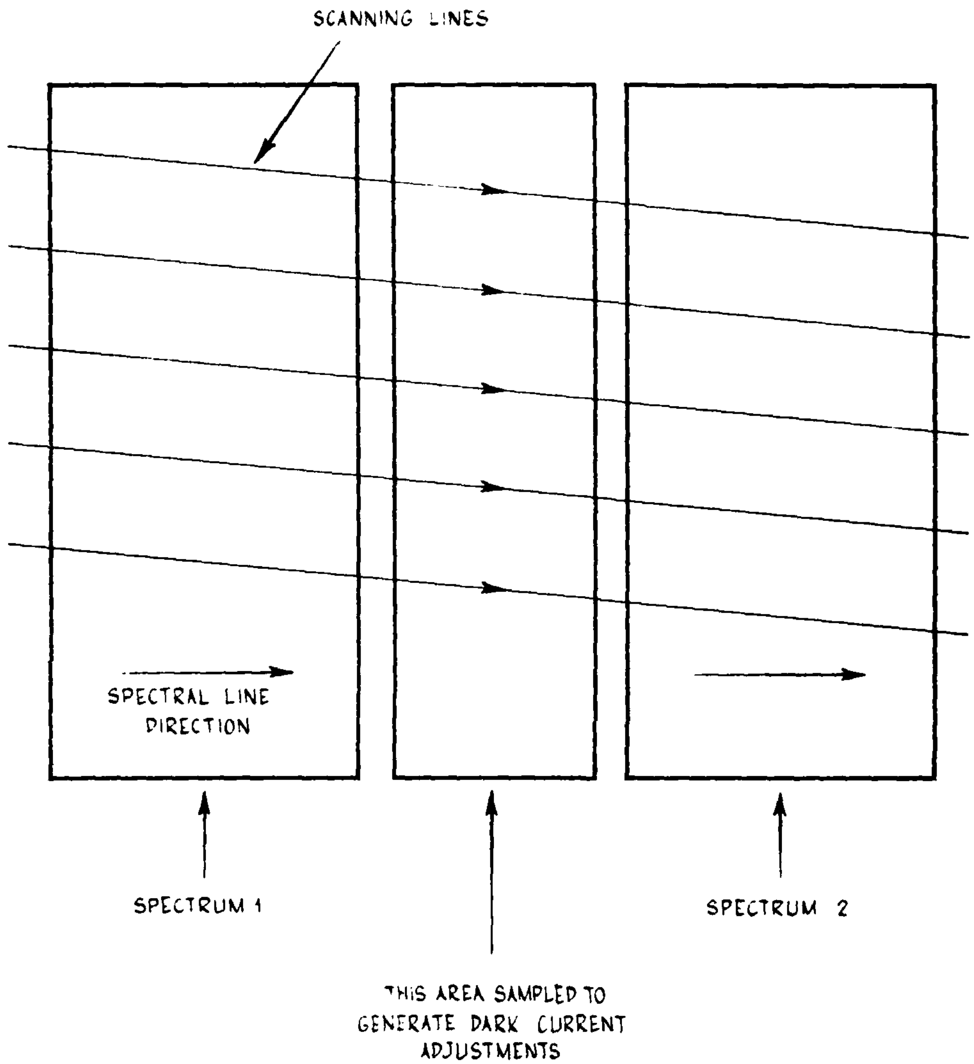

Figure 2. Spectra disposition on image tubeface

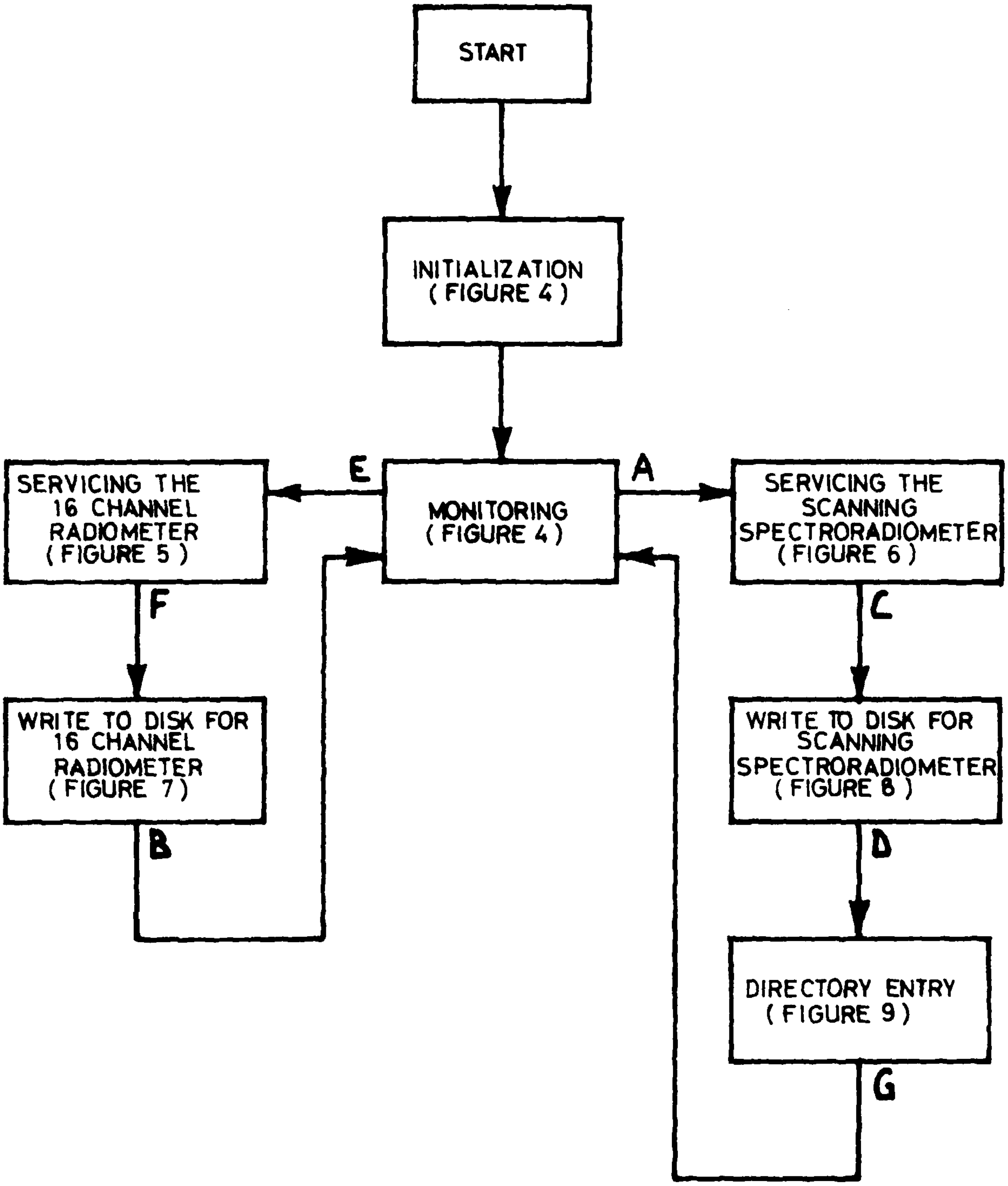

Figure 3. Block diagram of major flowchart functions

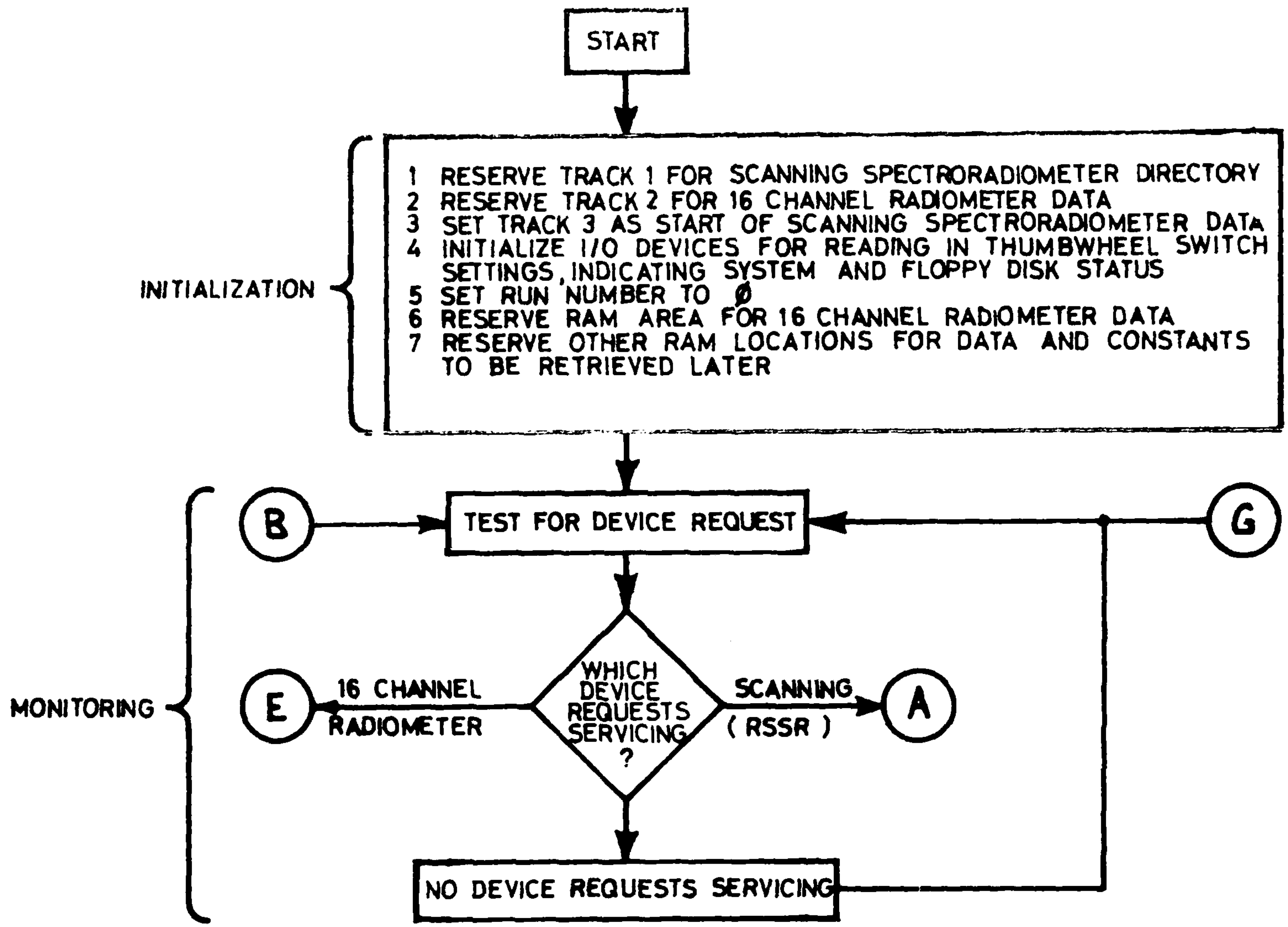

Figure 4. Initialization and monitoring

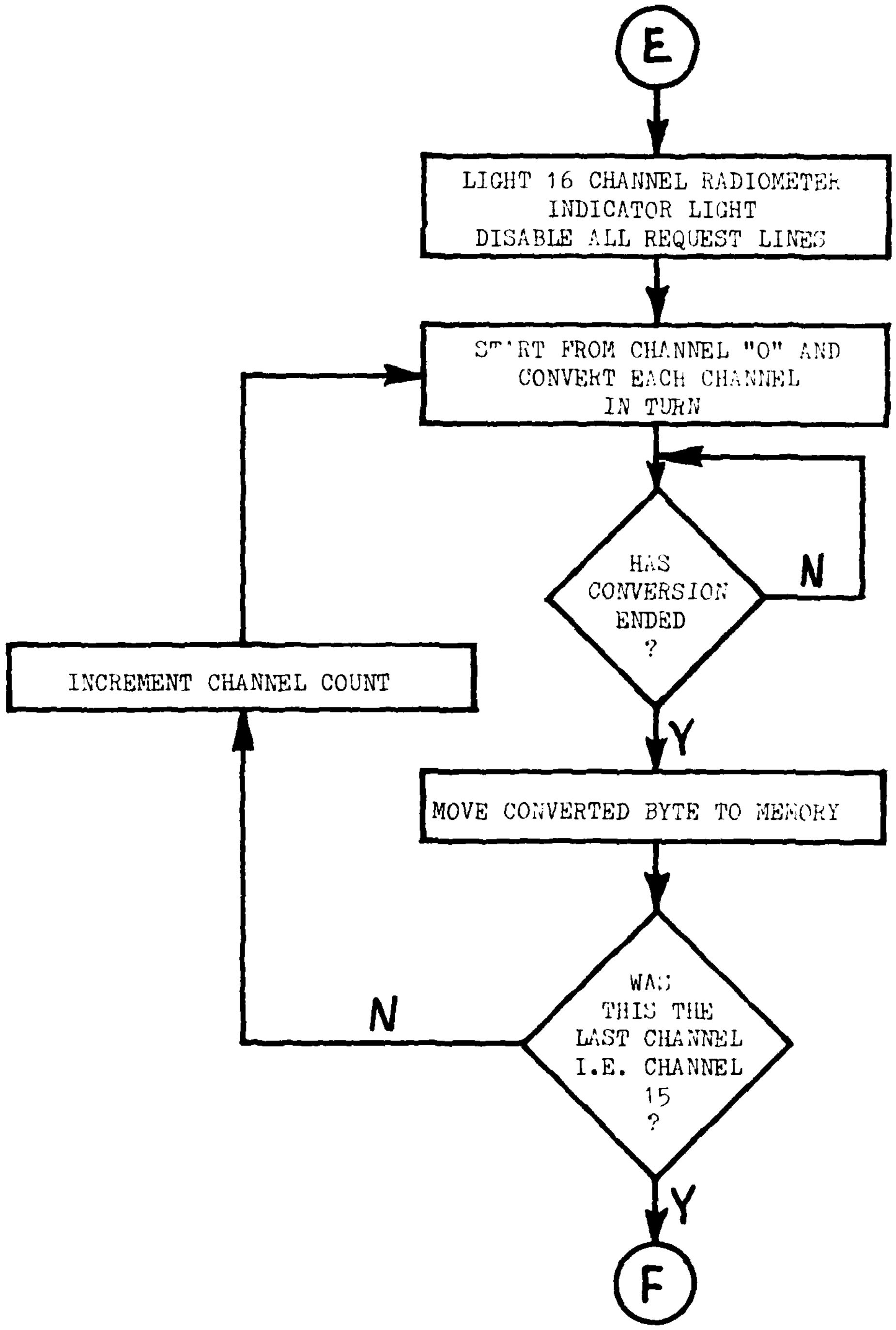

Figure 5. Servicing 16 channel radiometer

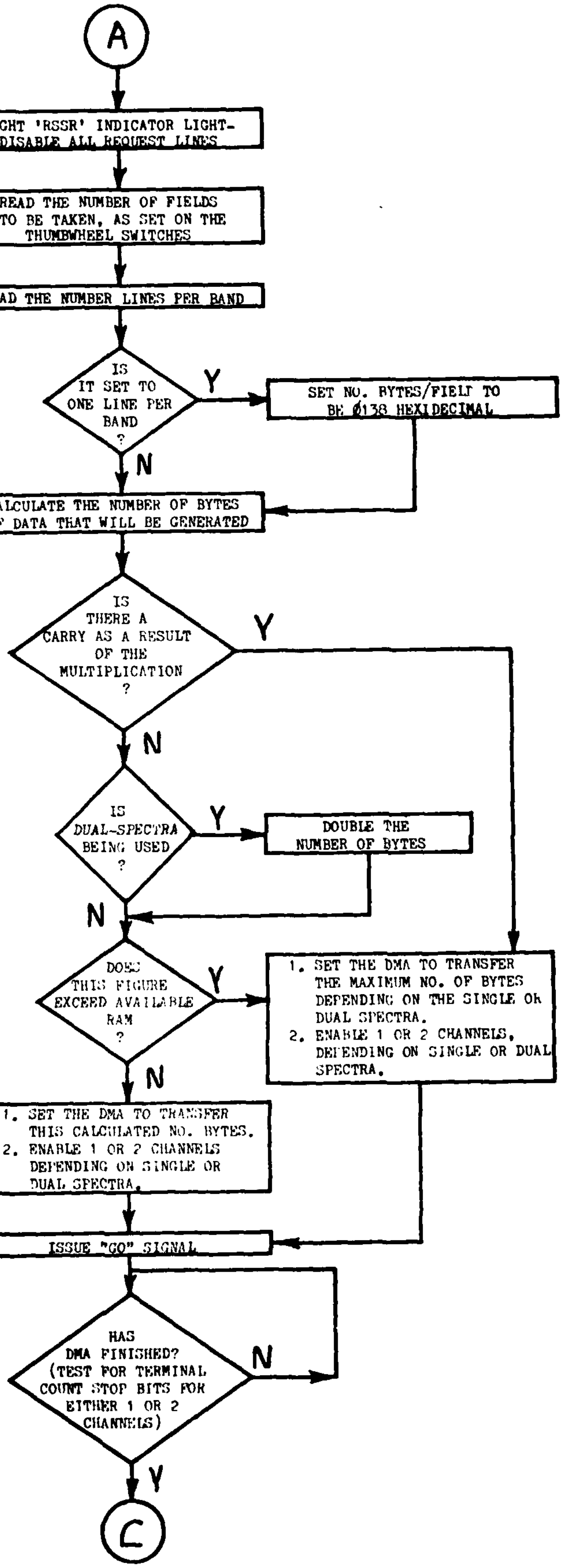

Figure 6. Servicing the scanning spectroradiometer

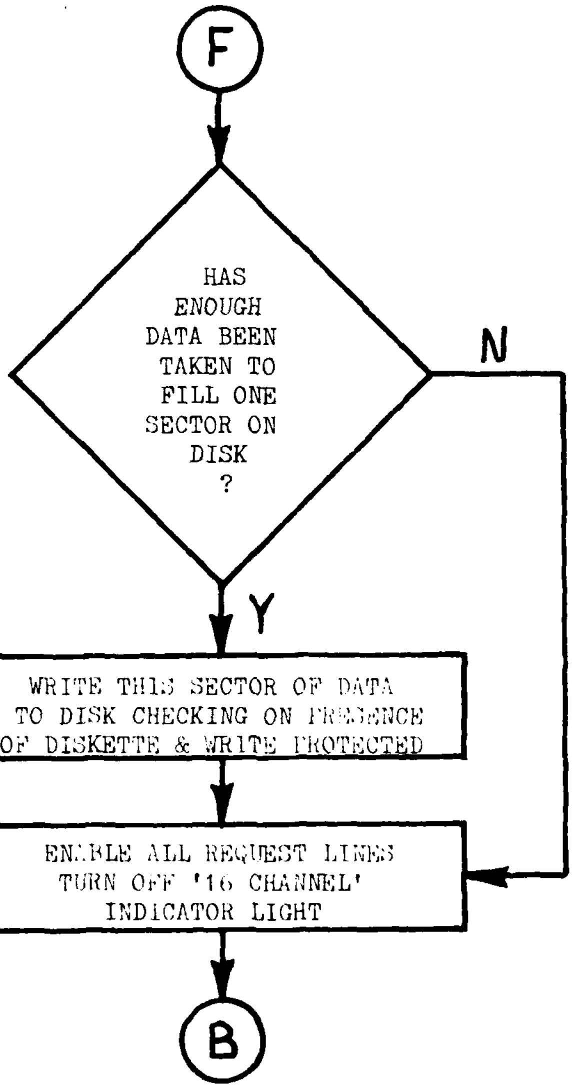

Figure 7. Write to disk for 16 channel radiometer

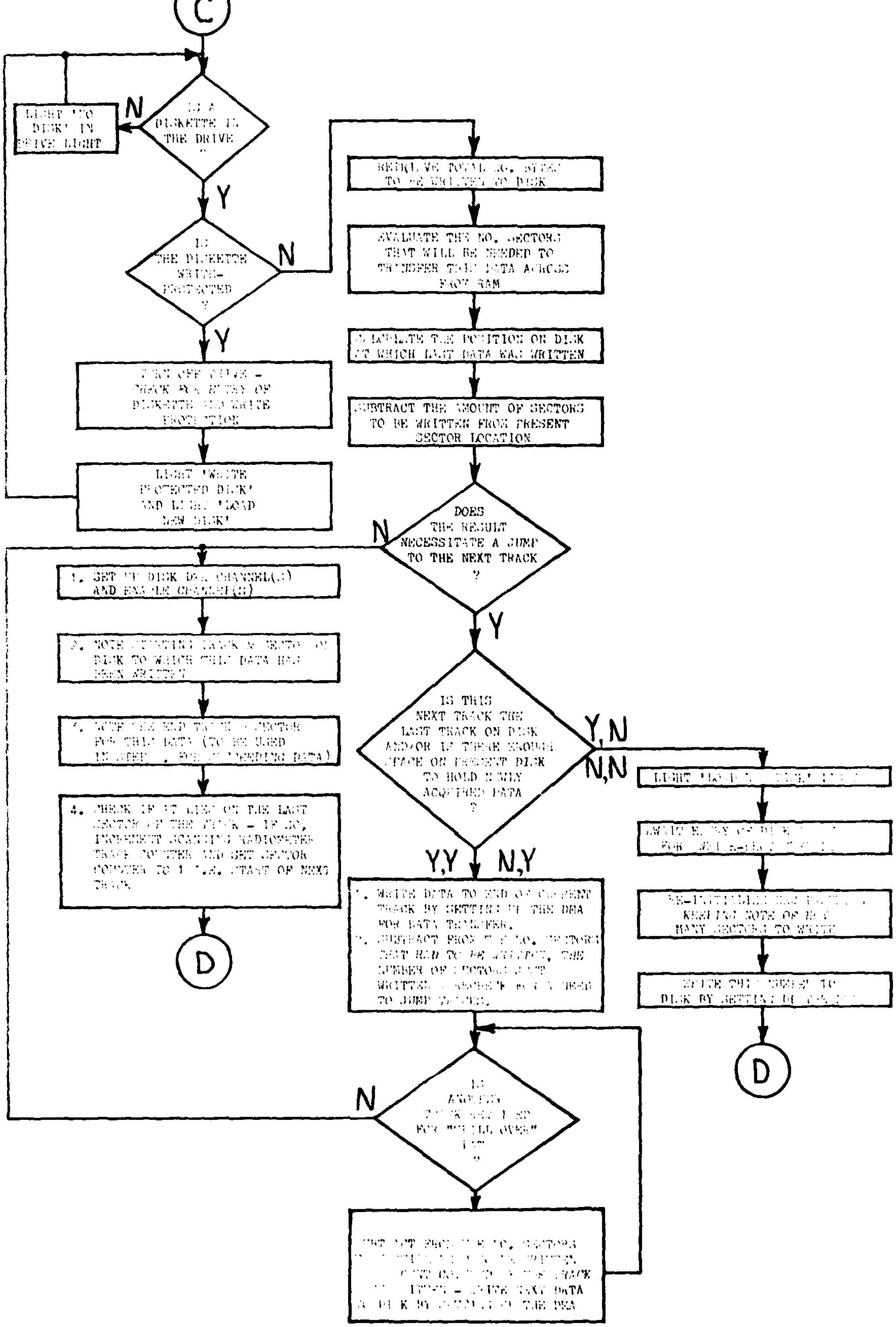

Figure 8. Write to disk for scanning spectroradiometer

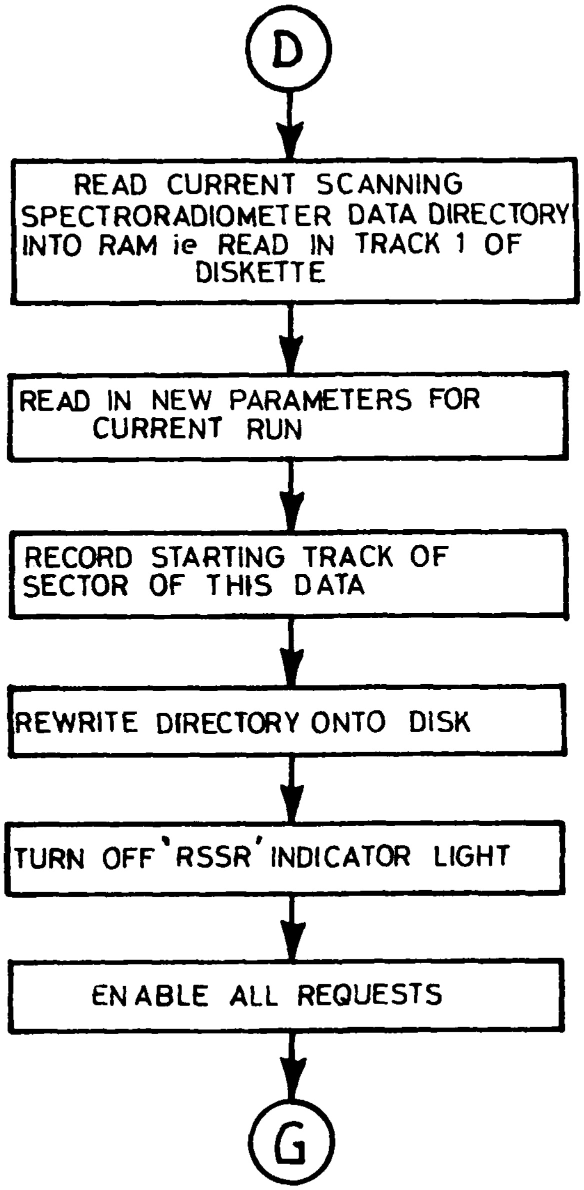

Figure 9. Directory entry for scanning spectroradiometer

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16 SUMMARY OR ABSTRACT:
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